DOCUMENT RESUME

ED 161 433 IR 006 397

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TITLE Computers for Learning: The Uses of Computer-Assisted Instruction (CAI) in California Public Schools.
INSTITUTION California State Dept. of Education, Sacramento.
PUB DATE 77
NOTE 15p.
AVAILABLE FROM Publications Sales, California State Department of Education, P.O. Box 271, Sacramento, California 95802 ($1.25)

EDRS PRICE MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS Changing Attitudes; *Computer Assisted Instruction; Computer Managed Instruction; Computers; Cost Effectiveness; Diffusion; Educational Innovation; Instructional Improvement; *Public Schools; *State of the Art Reviews; Trend Analysis

ABSTRACT

Implications of and resource information on the use of computer assisted instruction (CAI) in California public schools are presented under the following headings: (1) definition of CAI, (2) effectiveness of CAI, (3) obstacles to the use of CAI, (4) the turnaround in CAI acceptance and use, (5) instructional potential of CAI, and (6) how to obtain information on CAI. Subtopics discussed in these sections include drill and practice, problem solving, simulations, and tutorial formats; cost and availability of computers, curriculum quality, adverse attitudes; shifting economies, increasing expertise, changing attitudes; computer capacity, computer graphics; and computer demonstrations, other educators, computer programing, shopping for computers. (CMV)

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The Uses of Computer Assisted Instruction (CAI) in California Public Schools

Computers for Learning

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IR006 397

Preface

The cost of computer hardware has been reduced substantially by the introduction of new technology. The digital watch, the hand-held calculator, and the $1,000 do-it-yourself computer kits are only a few examples of the products of microprocessing, a revolutionary new advancement in computing with integrated circuits. Today a broad selection of computers and systems is available to educators, with options ranging from the vast and sophisticated, time-sharing systems that serve thousands of students simultaneously to the inexpensive ($1,000) general purpose, single-terminal microcomputer that serves one student at a time.

Cost reductions resulting from advancements made in the microprocessing technology have put Computer Assisted Instruction (CAI) hardware within the reach of the public school budget. In addition, advancements in courseware development have made it possible for children to make significant gains in basic skills by using CAI. These and other developments are responsible for the increase in the number of purchases of CAI by California schools over the past two years.

Many educators are not aware of this increasingly popular learning resource and its potential as a future instructional tool. Therefore, this publication is intended to provide general information on the state of the art of computer technology. School districts that are "window shopping" for CAI systems may need assistance of a more technical nature. They should obtain the advice of consultants who are experienced with instructional uses of computers, communicate with school districts that have CAI experience, or contact the Educational Technology Unit, California State Department of Education, 721 Capitol Mall, Sacramento, CA 95814 (916) 445-5065.

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Acknowledgments

Gratitude is expressed to the following persons for their assistance in the preparation of this publication:

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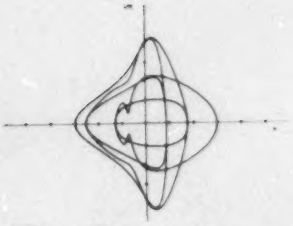


Definition of Computer Assisted Instruction

Computer Assisted Instruction (CAI) is a process in which the learner interacts directly with lessons which are displayed on a cathode-ray tube or which are printed by a terminal that provides hard copy. The lessons are presented in the drill and practice, problem solving, simulation, and tutorial formats.

Drill and Practice Format

The drill and practice format helps students to master the subject after the concepts have been taught by the teacher. Student errors are corrected immediately in a nonthreatening and nonhostile atmosphere, and correct responses are positively reinforced. Drill and practice programs in elementary reading and mathematics have generated positive evaluation results throughout the country. Experimental groups in mathematics have demonstrated impressive gains, with the most impressive results among boys, particularly fourth graders and low ability students (Taylor, 1974). In research projects involving language teaching, students in CAI experimental groups performed better in reading and writing than the conventional language laboratory students (Taylor, 1974). The computer assisted instruction drill and practice format appears to provide powerful instructional assistance in the education of ethnic minorities, ostensibly attributable to its effect on "locus of control" (Crandall, 1975).

Problem Solving Format

The use of CAI for problem solving helps students to obtain a deeper understanding of problem solution strategies (Naval Personal Research and Development Center, 1975). Problems are presented by the computer to the students, and the students program their own solutions. Tedious and repetitious calculations, as well as resource information, are provided by the computer. By using computerized problem solving, the students become involved with mastery of concepts, patterns, structures, and relationships, which lead to an understanding of the problem *gestalt*. Mathematics has been the principal subject area for the use of the problem-solving mode, but it has also been effective in many other subject areas. In mathematics, for example, iterative techniques are more commonplace and more understandable to students (such as the estimate-divide-average method of determining the square root of a number) because of the computer and its ability to perform repeated calculations at blinding speeds. The computer has also made logarithms and trigonometry tables available at the touch of a finger and has cast a completely new light on their use in secondary mathematics.

Simulation Format

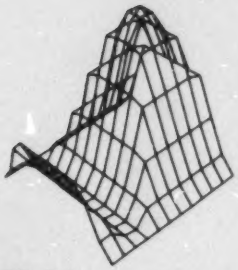
In the simulation mode the student is given the necessary data about a particular problem or system and is then asked to carry out an assigned task by using a number of alternatives available to him or her. The student learns from the ultimate results, which are presented on the computer terminal, the consequences of the alternatives that were chosen. Simulation allows the student to experiment; and, in the process of experimenting, he or she becomes familiar with the forces which are at work. In science and social studies, simulations are used to perform vicarious experiments that are either too impractical, too costly, or too dangerous for the school laboratory. Research has shown that computer simulations help students learn concepts faster and with higher achievement gains on pretests and post-tests than students learning in conventional ways (Naval Personnel Research and Development Center, 1975).

Tutorial Format

In the tutorial mode the computer acts as the teacher. It teaches the concept, works toward mastery through drill and practice, tests comprehension and performance, corrects learning errors, and retests. Experiments showed that learning

gains were higher for CAI tutorial students and that instructional times were reduced, thereby making learning more efficient. More material was presented through CAI tutorials than through conventional courses.

Early experiments in CAI at Stanford University, the University of Illinois (PLATO), and Brigham Young University (TICCIT), and at many other schools, colleges, and universities throughout the nation contributed to the current development of CAI. These experiments, although very expensive, produced thousands of curriculum materials or programs that are being used successfully in many subject areas and at all grade levels. Such accomplishments have demonstrated CAI's ability to affect learning positively at the classroom level. With the reduction in the cost of hardware and the continual refinement of existing curricula, CAI, no doubt, will be used more extensively in public schools.



Effectiveness of CAI

The one question usually asked by educators is whether or not CAI teaches effectively. It is reasonable to require that any innovative instructional system meet the crucial test of instructional effectiveness. The results from many years of careful research and development in CAI are very positive as to its effectiveness as a learning tool. The following commentary, supported by evidence from sixteen studies, is typical of the conclusions reported in the literature:

> We have found strong and consistent achievement gains by students when they are given CAI over a reasonable fraction of a school year . . . . CAI can be used or abused . . . . The point we want to make is that CAI is an extremely effective tool and that used properly it presents a serious possibility for the improvement of education (Fletcher, Suppes, and Jamison, 1972).

Examples of other comments on the effectiveness of CAI are as follows:

> Computer assisted experimental groups demonstrated significantly higher achievement levels (Ronan, 1971).
>
> There were high correlations between "on-line" rate of progress and student's achievement on standardized tests for CAI in reading (Campbell, 1975).
>
> Fourth and fifth grade CAI students were able to manage effectively their learning in elementary mathematics and to learn faster and retain better than control groups (Jacobson and Thompson, 1974).

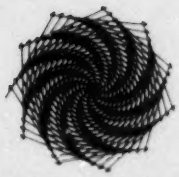
The most conservative review stated that CAI is at least as effective as traditional instruction (Naval Personnel Research and Development Center, 1975). In 1975, Nelson D. Crandall of the Los Nietos Elementary School District, Whittier, California wrote:

> In the field of compensatory education, practitioners have been led by a succession of Messiahs who showed them the way. Each time the promised results did not materialize, yet the practices lingered for want of something better. As a result, educators have become increasingly skeptical of programs claiming success in raising achievement levels with children from proverty background. To the uninitiated, proposing that achievement levels may be raised in children by having them sit in front of a computer terminal for fifteen minutes a day seems ludicrous. But the facts are in. Standardized test scores have soared with children doing drill and practice on a daily basis using CAI.

Crandall also reported that the rate of truancy and tardiness decreased with the implementation of CAI, that children made intensive use of the computer terminal before and after school, and that a decline in vandalism was noted at school plants.

The positive results of CAI research were also reported by public schools in New York, Florida Oklahoma, Pennsylvania, Texas, Illinois, New Mexico, Mississippi, and Washington (Macken and Suppes, 1976). Research conducted in 1971-72 in Montgomery County, Maryland, showed that CAI students made significantly greater gains in mathematics than their counterparts did in traditional classrooms; that it was possible, with computer assistance, to enlarge geometry classes with no decrease in achievement; and that teachers who used CAI were able to spend more time with individual students (Morgan and Richardson, 1974).

Achievement results were based primarily on experience with drill and practice uses in reading and mathematics. These applications have been studied more extensively in the research. Other promising applications now under development will undoubtedly be the subject of further research.



Obstacles to the Use of CAI

The principal obstacles to the widespread use of CAI in the public schools in the past are believed to have been the cost and availability of computers, lack of quality curriculum, and adverse attitudes toward new technology.

Cost and Availability of Computers

Computer assisted instruction has been expensive. The high costs have been due largely to the state of art, which has forced CAI users to rely on time-sharing from large centralized computers with priorities in the field of business applications. Such arrangements have adversely affected the quick response time necessary for successful interactive learning that the computer is so well equipped to provide. Up until now, large computers have been very costly, keeping them out of the reach of locally funded school districts.

Curriculum Quality

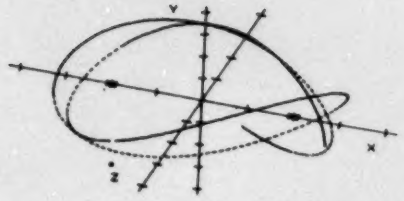
In the early days it was difficult to find personnel who were expert in computer programming and curriculum development, both of which are highly specialized stages of separate disciplines. Computer experts, excited about educational applications, often demonstrated and sold curriculum materials that were regarded by teachers as trivial and ineffective. Educators who were familiar with the complex problems of learning generally were not aware of the capabilities of the computer in addressing those problems. A number of years of experimentation, development, and cross-training were required to produce programs that were sufficiently germane to improve instruction.

Adverse Attitudes

Unfortunately, computers and people have been placed in adversary roles. The rapid development of the computer in society has produced a kind of future shock. The gap is large between what computers can do and the layperson's understanding of how they do it. This gap causes suspicion and uncertainty that tends to obscure people's vision of the future. Publishers and media people have capitalized on these fears in writing for entertainment markets. The resulting fiction has made good copy for the publishing industry but has created a less-than-objective view of the contribution of the computer to the problems of society. Admittedly, new technology has given rise to new problems, but those problems have been distorted and exaggerated in popular folklore.

The newness of CAI, coupled with the mystique, the distrust of anything new, and the early claims of technologists that computers would replace teachers, raised anxiety levels of educators and kindled sparks of resistance. Additionally, the computer possessed its own body of skills and vocabulary that were not easily assimilated by already beleaguered instructional staffs. Introduction of CAI in its developmental stages could not compete with other commanding priorities on the overcrowded agendas of staff development meetings, even though the computer offered promising resolution to many of the problems of education. Because of these factors, educators have failed to infuse the computer into the educational process to the extent that would seem justifiable by the positive results of effectiveness research.

Significant developments in the state of instruction and in computer technology over the past decade have softened the obstacles and heightened the probability of acceptance of CAI as a valuable tool of learning. Such a trend is evidenced by the phenomenal increases in the use of CAI throughout California public schools in recent years.



The Turnaround in CAI Acceptance and Use

In the past decade educators have become more and more aware of the usefulness of the computer. While it has contributed substantially to administrative tasks such as budgeting, accounting, planning, scheduling, and evaluation, the computer's usefulness has also been increasing in the fields of counseling, management of instruction, and in direct instruction. Evidence of a turnaround in acceptance of the computer is provided by a comparison of recent school district expenditures for purchase of computers and computer systems with the expenditures for similar equipment and systems a decade ago. This change can be attributed to a well-documented shift in the economics of computing, increased sophistication in computer curriculum development, and maturing attitudes about practical applications of the computer in our daily lives.

Shifting Economics

The microprocessing revolution has dramatically reduced costs of computer hardware. Computer capability that cost about a quarter of a million dollars ten years ago can be purchased today for considerably less than $100,000. Terminals that cost upwards of $2,000 can now be purchased for under $1,000. Today a kit-type, do-it-yourself computer can be purchased for $1,000. One manufacturer has announced a new, eight-user, time-sharing microcomputer system that sells for less than $4,000 without terminals.

While these small machines may not have sufficient storage to provide individualized curriculum in complex curriculum strands for whole subject areas, they do have many useful purposes, such as storage and retrieval of tables for mathematics and science classes or simple drill and practice exercises in spelling. These capabilities portend many promising developments for the future of education.

The optimum configuration that seems to be meeting with success in education today is the minicomputer, which has thirty-two terminals that provide drill and practice in elementary reading and mathematics. Such systems are daily increasing the students' achievement scores on commonly used standardized tests. They sell for approximately $40,000, plus recurring costs for curriculum and maintenance.

Space requirements for computers have also been reduced substantially. The first computer required a very large room to contain the many vacuum tubes that made up its central processing unit. Today, a minicomputer occupies the same space that is occupied by an average size filing cabinet. A small microcomputer, which serves one student at a time and operates on standard house current, can be located on the top of a desk or table of a mathematics, science, or elementary school classroom, or can be moved from room to room on a cart.

Funding for computers is becoming increasingly available in education. Districts that have already purchased computers for business purposes are in a good position to provide instructional services as long as they are able to identify appropriate uses of the computer in the curriculum, and they can modify time-sharing priorities. One California district with modest means, which started by installing a terminal connected to a neighboring college computer, has grown to the point where it offers CAI services to surrounding school districts. An inner-city district purchased computers for business education programs that resulted in the placement of their computer science-trained graduates in a very competitive labor market. This district has expanded from vocational training to providing computer services in CAI to many other schools in the district. The United States Office of Education has funded CAI reading and mathematics projects in schools that qualify for Emergency School Aid Act monies. At least one district in California today is purchasing microcomputers from local funds for mathematics and science classes in all of its secondary schools.

Today, many systems are available that provide a variety of services to instruction for a variety of costs. Educators who are considering the purchase of computer systems should carefully analyze the potential uses of the computer, plan for inservice training needed to integrate the computer into the regular curriculum, and, in the process of shopping, be aware of such factors as hardware reliability, response time needed for interactive learning, software (curriculum materials) costs, transferability between computer languages and systems, and potential costs for maintenance. If these factors are carefully considered, a cost-effective computer system can be an important factor in the improvement of student achievement in the schools.

Increasing Expertise

The nature of computer programming has required from the very beginning that learning materials be prepared in a systematic manner so that motivational interaction is provided between the student and the curriculum. Through many years of experimentation and research, curriculum designers and computer programmers have learned to fuse their skills in the production of a superior product. As a result of the rigorous controls and procedures imposed during the developmental stages, such as teacher imput into design and validation in the classroom setting, CAI has produced positive effects that are observable in practical application.

In pretest and post-test results, CAI students have gained significantly in the mastery of elementary reading and mathematics. These gains are attributable to advances such as increased ability to individualize and personalize instruction and increased student motivation through interaction between the student and the program.

Individualization presents a task so formidable that it is almost unattainable by teachers without the help of technology. The capability of the computer to store and retrieve massive amounts of data instantaneously is providing up-to-the-minute individual data on the performance and progress of large numbers of students in each detailed strand of complex curricula. These data are being displayed on cathode-ray tube terminals without delay and are being printed immediately in hard copy for later review and reference by teachers.

Motivation for learning is greatly enhanced by CAI, as any observer in California classrooms can witness. In some cases it is not unusual for students to linger at the terminal, to come before school, or to stay after school and work on the computer drill and practice lessons. Such intrinsic motivation sometimes leads to a situation in which incoming students exhibit impatience with students who do not want to relinquish the terminal. This phenomenon does not taper off after a short period of novelty, but persists as long as the students work with CAI over several years. Crandall (1975) has given some insights to the reasons for this positive motivation. He pointed out the value of the computer in helping *externally controlled* students to become more *internally controlled* individuals. He stated that, in the education of ethnic minorities, CAI helped students to reinforce the notion that outcomes were linked to their own performance rather than to some external force.

Changing Attitudes

Experience and research are beginning to dispel many myths about the computer, such as the common image of the computer as a cold, mindless machine that threatens to make automatons of the students and to replace the teachers. The testimony of teachers with long experience in the use of CAI tends to discredit such notions and supplies ample evidence that an even closer student-teacher relationship has developed with the help of CAI. Such developments have become possible because of careful emphasis on teacher involvement in the development of programs. Bork (1973) commented as follows:

> My experience shows that really effective materials are still coming almost entirely from those who are very much involved in the teaching process.

The close student-teacher relationship brought about by CAI usage has not been accidental, but has resulted from conscious efforts of CAI developers to do the following:

1. Combine the specialized skills of curriculum development and computer programming in the development of CAI lessons.

2. Develop and field test all materials in the classroom setting.
3. Systematize the presentation of materials in a manner that is psychologically sound without regimenting the student.
4. Conduct personable dialogue with students in the instructional program.
5. Design instructional programs for branching and randomizing so that they meet the individual needs in all strands of the curricula.
6. Handle consistently and unemotionally the tedium of basic skills instruction that is based on sophisticated principles of positive reinforcement.

As experience continues to build up, developers of CAI materials are increasingly recognizing that teachers must not be replaced by computers. Falzetta (1973) stated that teachers are needed to facilitate learning and to merge the affective and cognitive domains in a blend that enhances achievement and performance. One experimenter (Bunderson, 1975) acknowledged the deficiency of CAI in answering the needs of the "why" askers, thereby implying that such needs must be met by teachers.

To mitigate the fears of teachers and to focus more accurately on curriculum uses of the computer, educational agencies should formulate philosophies and policies that place the relative roles of teachers and computers in a more accurate perspective. Such a statement might read as follows:

> Computer assisted instruction is a powerful extension of the teacher. It is a valuable learning resource that should be integrated into the regular flow of instruction rather than be considered as a separate or unique program.

With such a philosophy, educational agencies could provide teachers with needed assurance of their importance, while extending to them the promise that the computer can provide the solution of some of their most vexing instructional problems.

All of the aforementioned factors, coupled with the rising rate of computer purchases for instructional uses in California, show that attitudes are changing toward the computer. As costs continue to diminish and knowledge about the effectiveness of CAI continues to reach educational decision makers, it appears that the trend toward acceptance of CAI will continue until its use in education is commonplace.

Instructional Potential of CAI

Computers are becoming so small and portable that they can be brought into the classroom to perform a variety of instructional tasks. With the perfection of the *bubble memory*, which will eliminate the need for electronic tape storage, smaller and even more powerful computers will be manufactured. This progress, coupled with continual sophistication of the curriculum development skills, is certain to increase the educational use of computers in coming years.

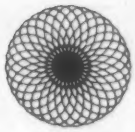
Computer Capacity

Already the computer has proven to be a dynamic and interactive teaching instrument, which is capable of (1) matching student needs with curriculum requirements; and (2) prescribing and presenting individualized and randomized exercises while instantaneously providing teachers with evaluative data about the progress of each student at any stage of the various curriculum strands. At the college level, teachers are using the computer tutorially for remediation and for presentation of their regular courses. Many college and high school teachers in California are able to bring into their classrooms today live experiments, simulations, and complex problem solving exercises that would be too costly, impractical, or even dangerous without the help of the computer. The computer's capacity for storage and retrieval of vast amounts of data in this age of exponential growth of knowledge is useful in levels of instruction ranging from direct tutoring to management of instructional resources.

Computer Graphics

The field of computer graphics offers a whole new dimension in learning. Through graphics, pictures, tables, and diagrams are being drawn on the CRT (cathode-ray tube) terminals at the command of the student or the teacher. This technology makes it possible to communicate concepts or sets of relations that were only teachable before through abstract explanations, complex narrative, or the use of lexical or numerical code methods on the computer. Through this development teachers will be able to use new theories of learning, such as the recently discovered right hemispheric development of the brain, in areas of understanding and knowing. They will also be able to meet head-on the challenge of accommodating a wider range of learning styles.

Based on the results of current CAI practices, it is possible to predict with high probability that major learning gains will occur in many subject areas as a result of the use of CAI. Education's foremost challenge will be in learning to use and to apply the existing technology. Once teachers and curriculum developers expand their efforts in developing CAI materials and in mainstreaming CAI into the regular process of instruction, education, like business and industry, will be successful in making the computer a powerful extension of the human being.



How to Obtain Information on CAI

Educators can obtain information on CAI by conducting manual or computer searches in the literature. They can also learn about the current developments and breakthroughs in technology by reading newspaper and magazine articles on the subject. However, these methods are time consuming and may be difficult for the busy public school teacher and administrator.

Computer Demonstrations

Demonstrations of computer systems by vendors are valuable in obtaining information. Most companies will send a representative to demonstrate CAI in the office or the classroom by use of a telephone linkup with their central computer. Often, in demonstrations, the uninitiated observers are mesmerized by the dazzling performance of the hardware and are unable to assess the value of the curriculum content. In spite of some disadvantages, such demonstrations are a necessary part of the information gathering process. Educators should consult more than one vendor and explore such factors as the evaulation of programs in instructional settings, transportability of programs from one hardware system to another hardware system, hardware costs, software costs, and maintenance costs.

Other Educators

The potential buyer of CAI will profit from discussion with other educators—provided that they have used CAI in the same way the buyer intends to use it; that they can produce evidence of its effectiveness in their instructional program; and that their commitment to a particular system is based on its success in the instructional program and not on other factors.

Valuable assistance may be obtained from full-time CAI consultants now employed in six California school districts. Such services are also available through the offices of four county superintendents of schools and the California State Department of Education.

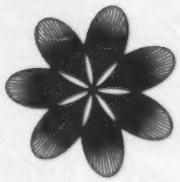
Computer Programming

Educators do not have to be knowledgeable in computer science to implement effective CAI programs. Knowledge of computer science, however, can be an asset. Once teachers and administrators are exposed to CAI uses in the curriculum, they will want to explore new uses, which may require specialized training and experience. Such training is available through most institutions of higher education. But teachers should exercise caution when they dispense with prepared programs and venture into teacher-made computer programs. Prepared programs generally are validated in a classroom setting, and their reliability is well established. Teachers may embark upon such an adventure after they have become more familiar with CAI, but they must understand that they will have to trade off validity for teacher control of programming at least in the initial stages of experimentation.

Teachers must realize that it is imperative to plan and train thoroughly for CAI just as for any other curriculum effort. They should be involved in the design for integrating CAI into their curriculum. Logistics, economics, and evaluation must be carefully undertaken. If involvement of teachers is sought and used throughout the decision-making process, a great deal more assurance is given that the system will be used as planned.

Shopping for Computers

Shopping for computer systems and CAI can be a sophisticated business, and educators must conduct thorough investigations. Computer experts are not necessarily education experts and vice versa. Computer assisted instruction is a discipline quite unique in computer science and in education. If experienced CAI consultants are used, and if staff members are involved in decision making, teachers and administrators will begin to recognize the value of CAI. They will begin to envision even more ways in which CAI can be used to enhance learning.



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